

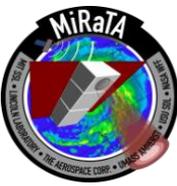
Nanosatellite Passive Microwave Radiometers: Microwave Radiometer Technology Acceleration (MiRaTA) and the Micro-sized Microwave Atmospheric Satellite (MicroMAS-2A)

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Rebecca Bishop, *The Aerospace Corp.*

June 12th, 2018



- **Motivation**
- MiRaTA Overview
- MiRaTA Status
- MicroMAS-2A Overview
- MicroMAS-2A Status



Hurricane Ike, 2008

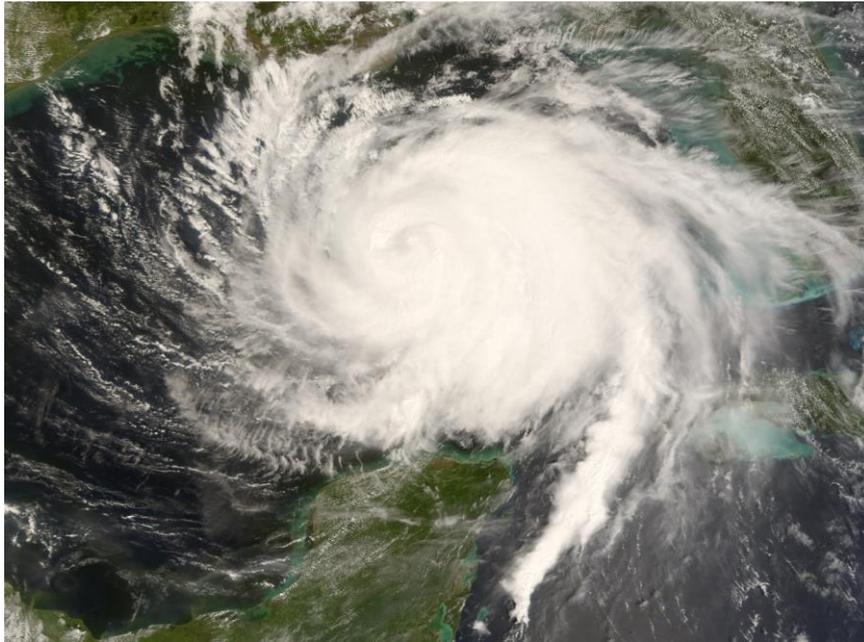


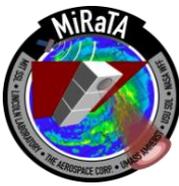
Image: NASA MODIS

Hurricane Ike damage, Galveston, TX



Image: NY Times

- The US derives \$32B of value from weather forecasts annually¹
- Severe weather events cost the US \$313.5B in 2017²
- Satellites that observe Earth drive the forecasts
- Need to observe the entire Earth, all the time, with quick availability, of temperature, water vapor, and cloud ice



MIT Roadmap to a Microwave Radiometer Constellation

NASA ESTO

MicroMAS-1

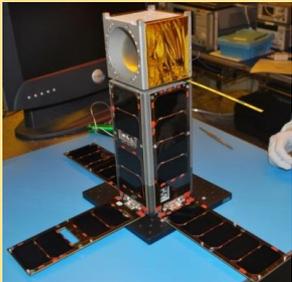
Scanning 3U CubeSat

Intended to measure 3D **temperature**

Launched in July 2014

ISS released it March 2015

Three successful contacts before radio failed



MiRaTA

- ~52-58 GHz (**temperature**, V-band)
- ~175-191 GHz (**water vapor**, G-band)
- ~206-208 GHz (**cloud ice**, G-band)

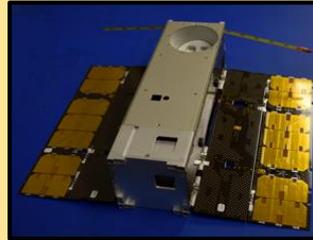
MiRaTA

Pitch-up 3U CubeSat

To measure **temperature**, **water vapor**, and **cloud ice**

GPS radio occultation to enable <1 K calibration

Launched November 2017 with JPSS-1



MicroMAS-2A

- ~89 GHz (**water vapor**, W-band)
- ~118 GHz (**temperature**, pressure, precipitation, F-band)
- ~183 GHz (**humidity**, precipitation, G-band)
- ~207 GHz (**water vapor**, G-band)

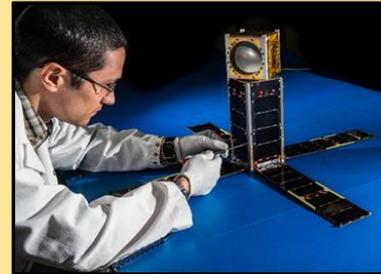
MicroMAS-2A & 2B

Scanning 3U CubeSat

To measure **temperature**, **water vapor**, and **cloud ice**

MM-2A: **January 2018**

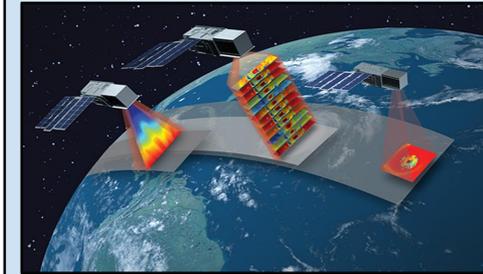
MM-2B: **Fall 2018**



TROPICS

Selected for EVI-3
6 CubeSats (3U) in three orbital planes
To measure **temperature**, **water vapor**, and **cloud ice**

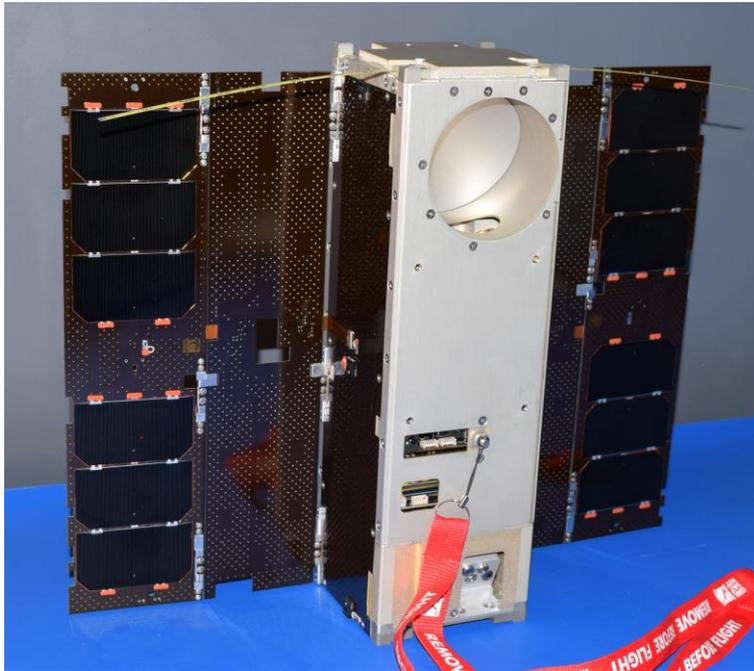
<60-minute revisit
2020 launch



NASA EVI-3
Earth System Science Pathfinder
Science Mission Directorate



As Built

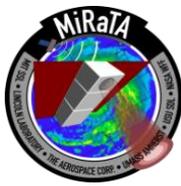


Launched with JPSS-1 (NOAA-20)



Image: NOAA

Nov 18, 2017



- **Launch Nov. 18, 2017 from Vandenberg**
 - Nominal early orbit operations
- **Early Orbit Operations**
 - Detumbling not attempted
 - Radiometer and CTAGS turned on successfully
 - Payload data went to Cadet radio buffer
- **Mission anomaly Dec 14th**
 - Downlink of payload data unsuccessful
 - Lost contact with spacecraft computer
 - Unable to recover computer or Cadet radio



- **Mission anomaly Jan 31st**
 - Lost backup radio
 - Ongoing anomaly investigation
 - Periodic contact attempts unsuccessful



- **So close! ☹️ On to MicroMAS-2A**



- Motivation
- MiRaTA Overview
- MiRaTA Status
- **MicroMAS-2A Overview**
- MicroMAS-2A Status



MicroMAS: Micro-sized Microwave Atmospheric Satellite

- **MicroMAS-1:**

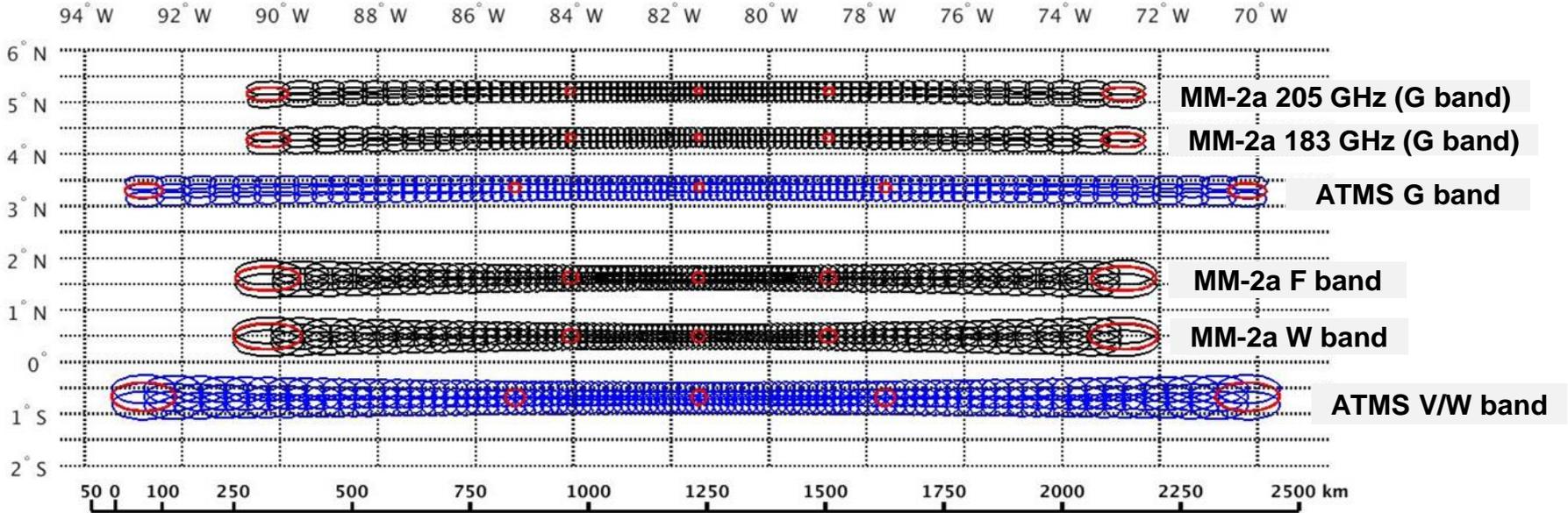
- 3U dual-spinner CubeSat
- High resolution cross track spectrometer
- 9 Channels in 118 GHz band

- **MicroMAS-2 is a follow-up mission to MicroMAS-1**

- 3U dual-spinner CubeSat
- High resolution cross track spectrometer
- 10 Channels, 4 bands
 - 89 GHz – water vapor
 - 207 GHz – water vapor
 - 118 GHz – temperature, pressure, precipitation
 - 183 GHz – humidity and precipitation
- Beam width of 3°
- Swath of 1800 km; nadir resolution of 20 km
- **MM-2A launched Jan 11th 2018 on PSLV**
- MM-2B launch fall 2018



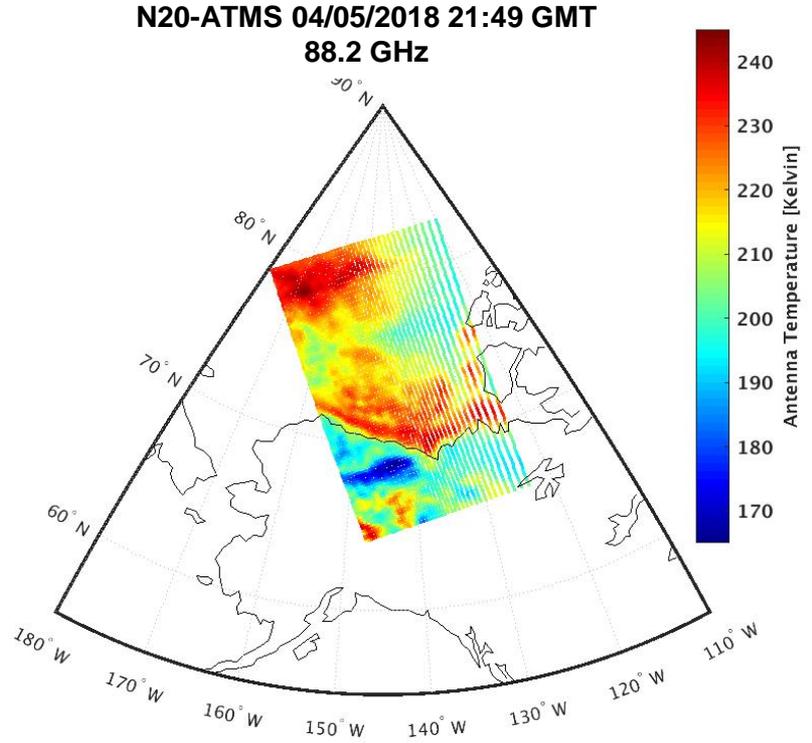
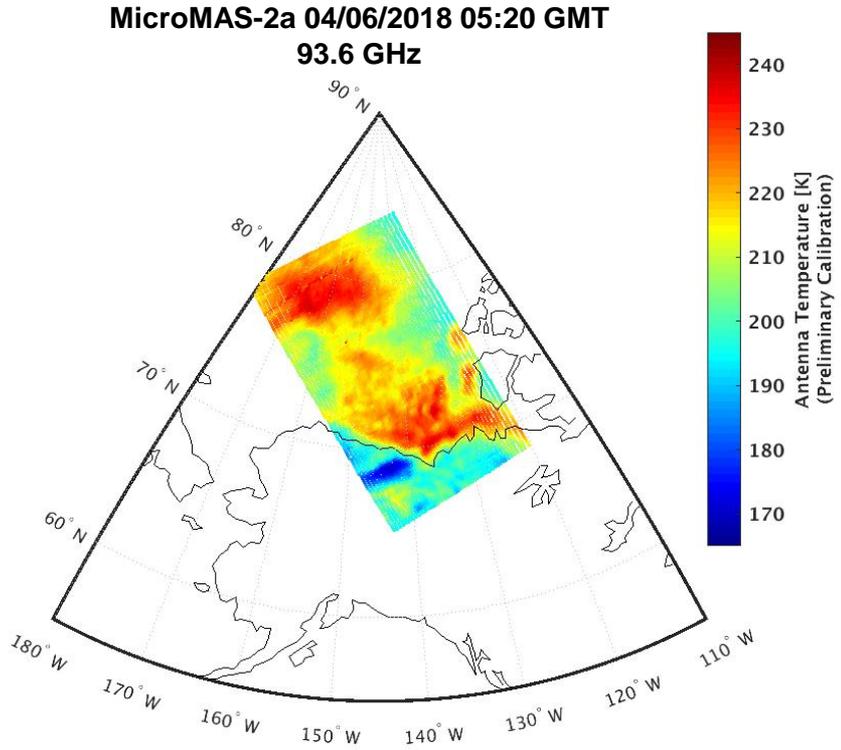
MicroMAS-2A:
4.5 kg, 34 x 10 x 10 cm³



Cross-track Sounder Footprints on the ground

MicroMAS-2a

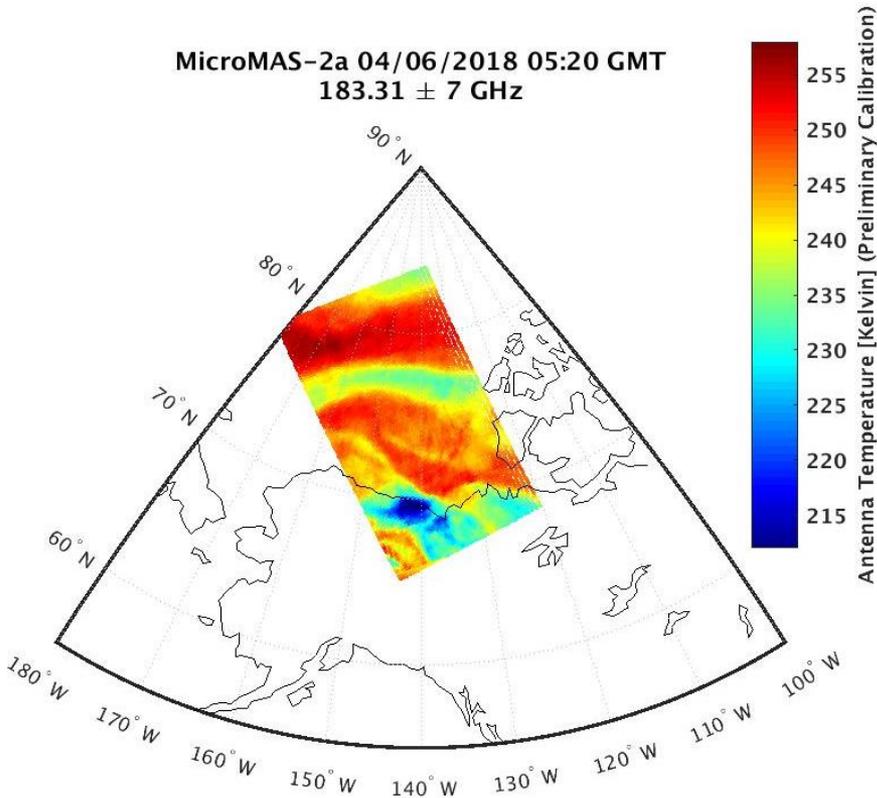
N-20 ATMS



First CubeSat Microwave Atmospheric Sounder Data!!

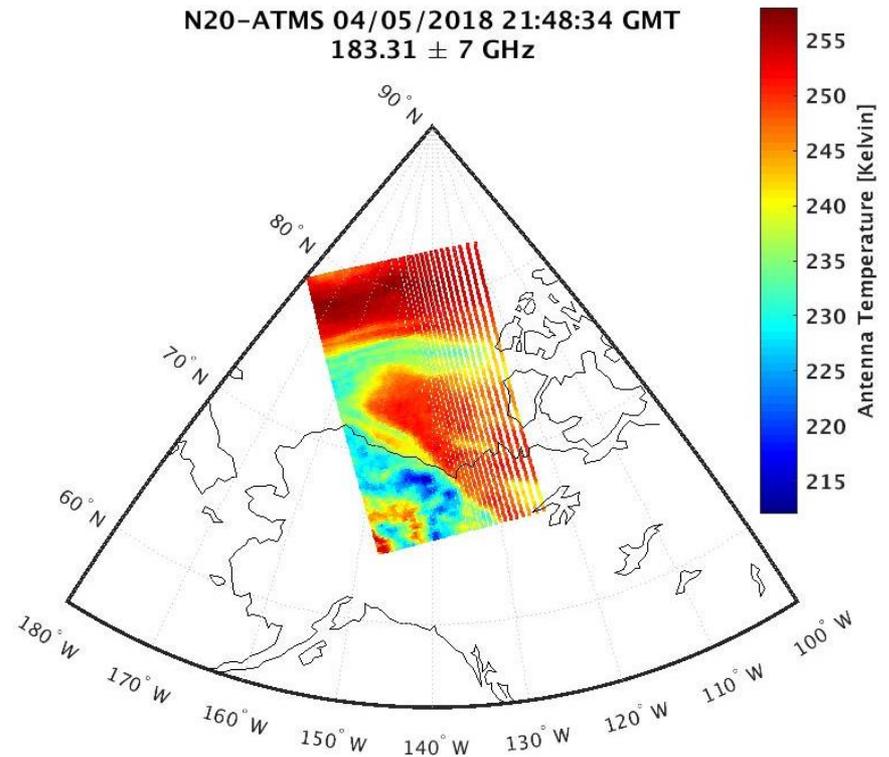
MicroMAS-2a

MicroMAS-2a 04/06/2018 05:20 GMT
183.31 ± 7 GHz



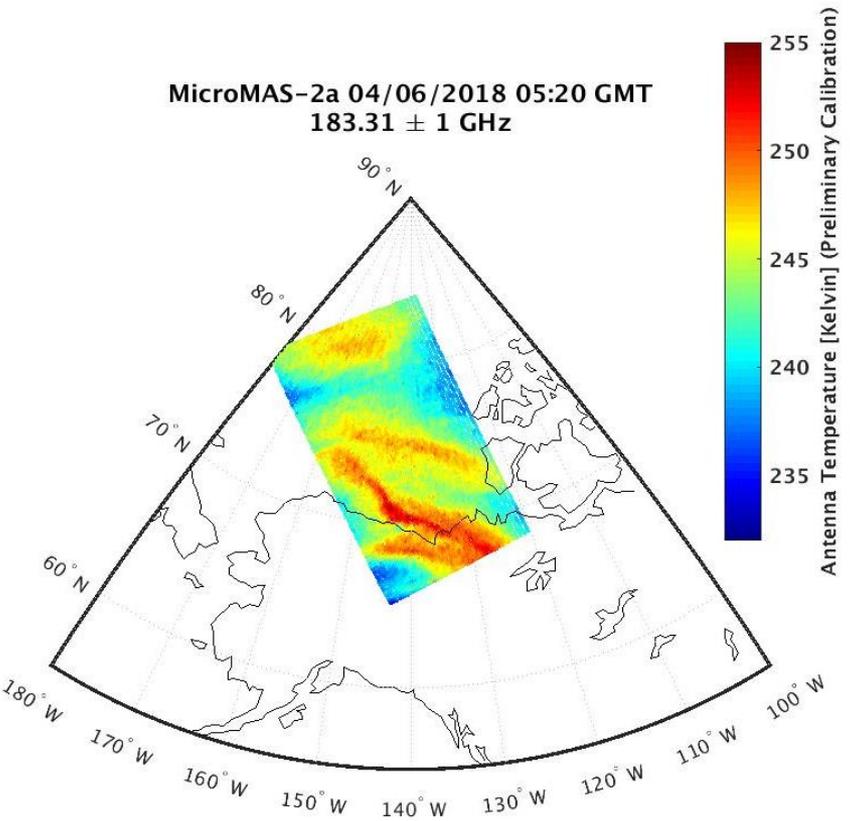
N-20 ATMS

N20-ATMS 04/05/2018 21:48:34 GMT
183.31 ± 7 GHz



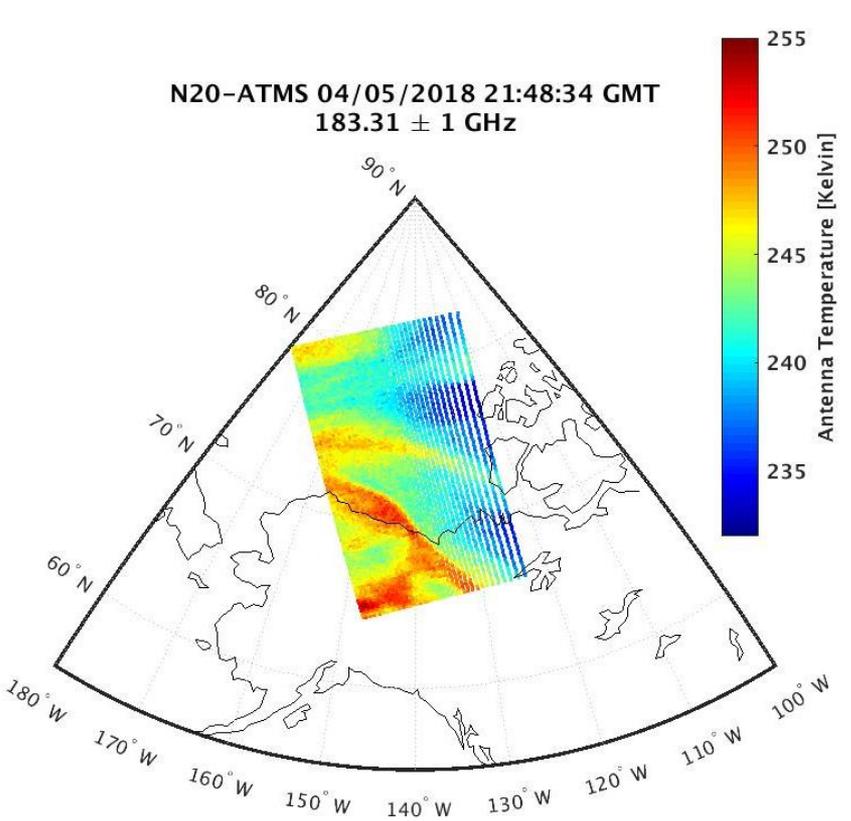
MicroMAS-2a

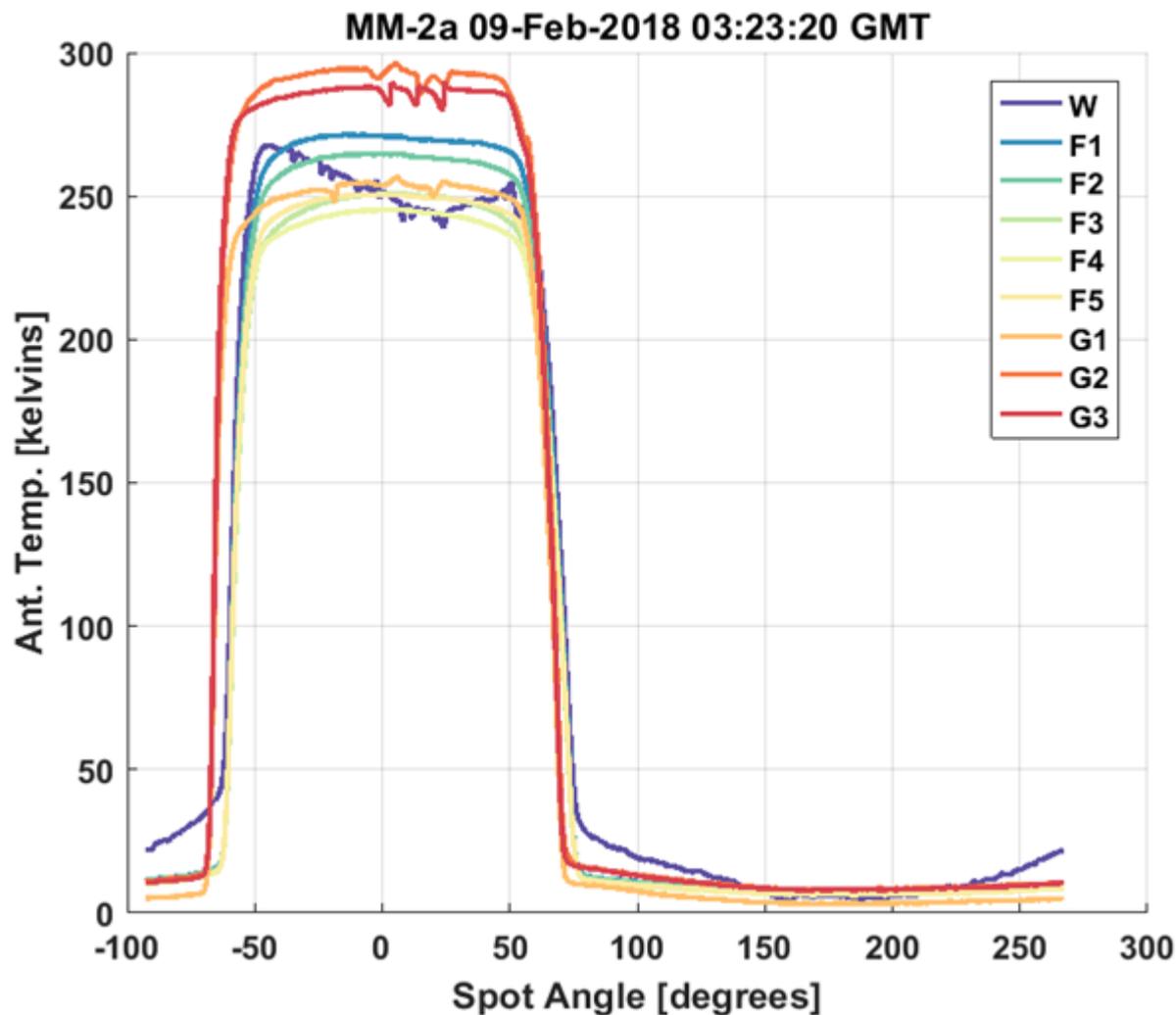
MicroMAS-2a 04/06/2018 05:20 GMT
183.31 ± 1 GHz



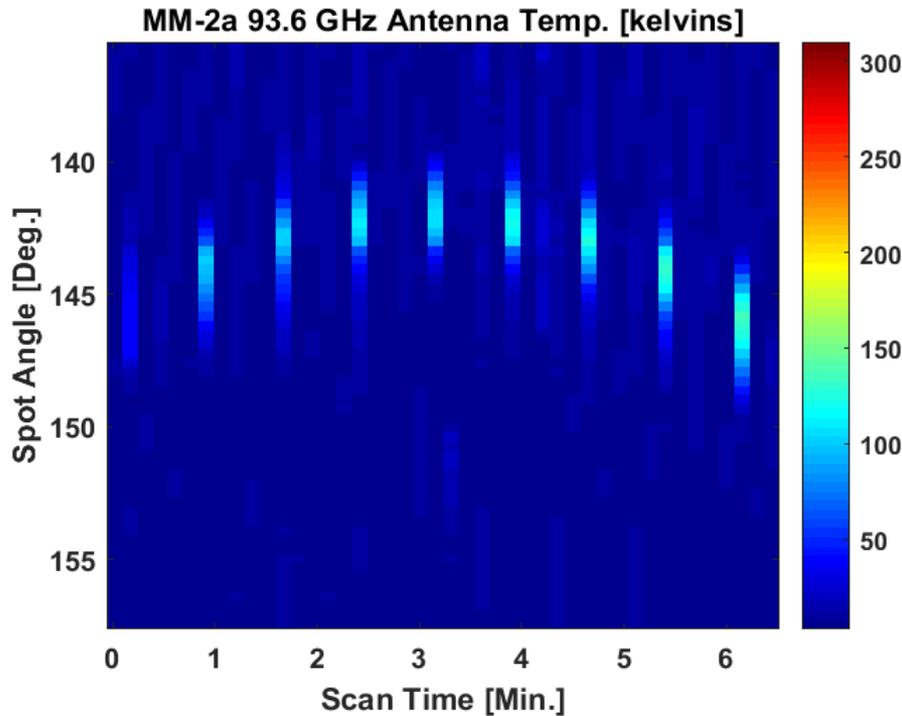
N-20 ATMS

N20-ATMS 04/05/2018 21:48:34 GMT
183.31 ± 1 GHz



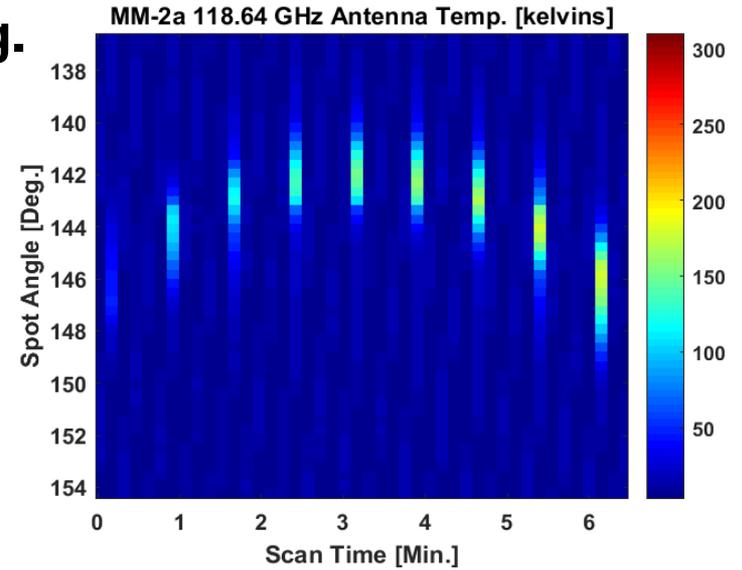


3.0 Deg. FWHM

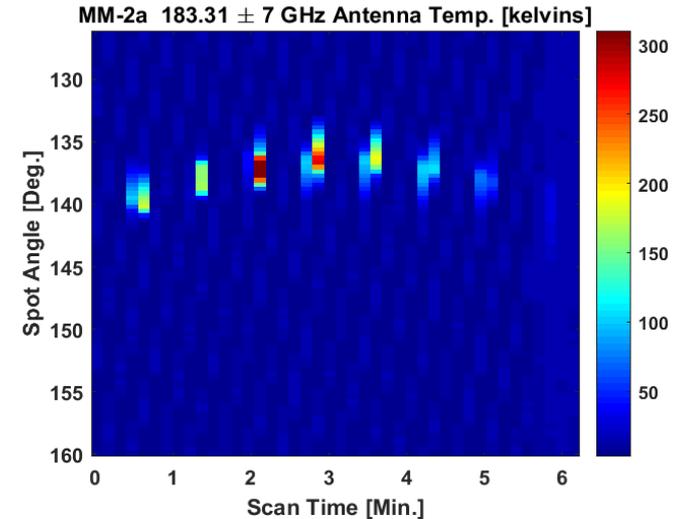


Sun is ~0.5 deg. disc

2.4 Deg.



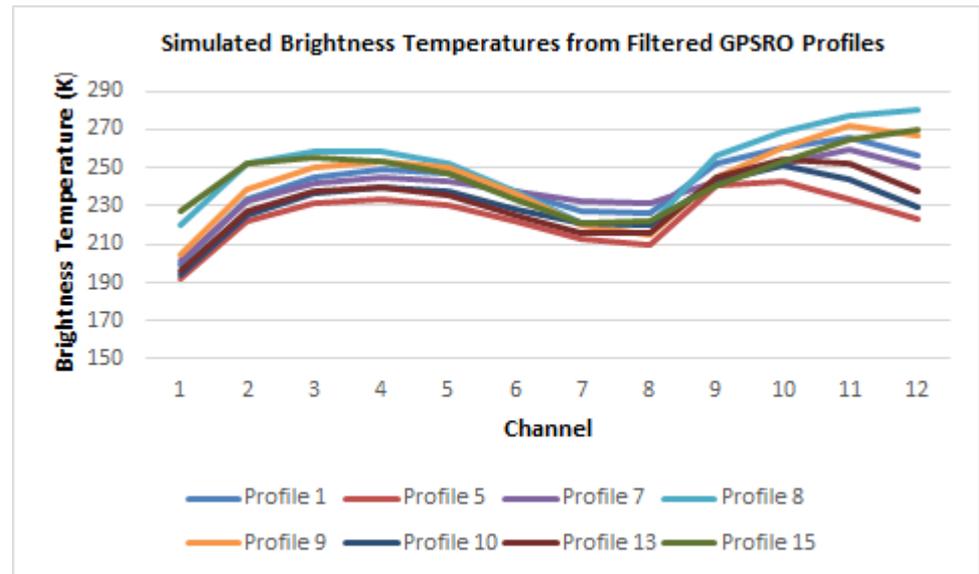
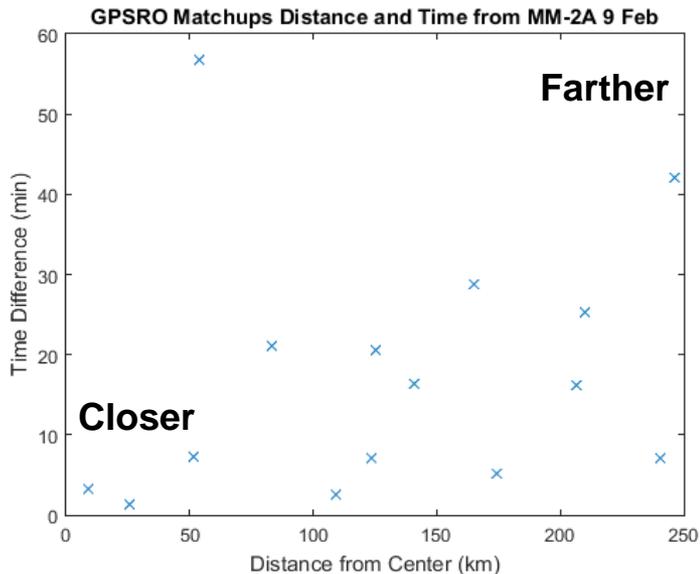
1.6 Deg.





Radiometric Bias Validation

- Community Radiative Transfer Model (CRTM) is used with GPS Radio Occultation (GPSRO) atmospheric profiles to provide simulated brightness temperatures
- Of the 15 possible GPSRO matchups with the MM-2A data, 8 were acceptable for radiometric bias validation





MiRaTA built, tested and flown and initial engineering data was acquired.

MiRaTA payload science data was not acquired due to an anomaly; investigation is nearing conclusion.

MM-2A data looks promising.

Future work will provide radiometric bias validation for MM-2A data using GPSRO, radiosondes, and NWP models.

